

## NASA NEWS: Year 4 Annual Report

Title: **Global analysis of ocean surface fluxes of heat and freshwater: satellite products, NWP analyses, and CMIP simulations**

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### **Project Description**

Careful analysis and blending of global satellite and NWP surface flux products, that are intercompared and evaluated against existing surface observations, are used to provide force ocean models and evaluate coupled climate model simulations. This product-driven NEWS proposal will:

- Evaluate the ocean surface fluxes and their input variables for available satellite data sets and NWP reanalyses for 1999, using the assembled SEAFLUX in situ data base
- Assemble a new “best” blended surface flux product
- Evaluate the blended flux data set in the context of basin net heat and freshwater fluxes and the implied meridional transports.
- Use the blended flux data set (combining satellite and NWP products) to force regional ocean models and to evaluate the U.S. CMEP models
- Produce a ~20 year blended flux data set for the period beginning with 1987.

### **Summary of Prior Accomplishments**

- Identify data discontinuities and trends in the new versions of satellite and NWP data sets
- Evaluation of the accuracy, precision, and uncertainty associated with surface fluxes and their input variables for available satellite data sets and NWP reanalyses for 1999, using the assembled SEAFLUX in situ data base

- Development of a 3 hour global skin SST analysis

We have completed the processing of the 3 hourly global SST data set at a resolution of 25 km that includes the diurnal cycle, for 1988-2004. Web site for dataset (<ftp://crew.iges.org/NEWS/JipingLiu/NEWS>).

- Begin comparison of CMEP simulations and calculations of net heat and freshwater budgets
- Southern Ocean sea surface temperature (SST) evaluation and analysis

### **Recent (Year 4) accomplishments**

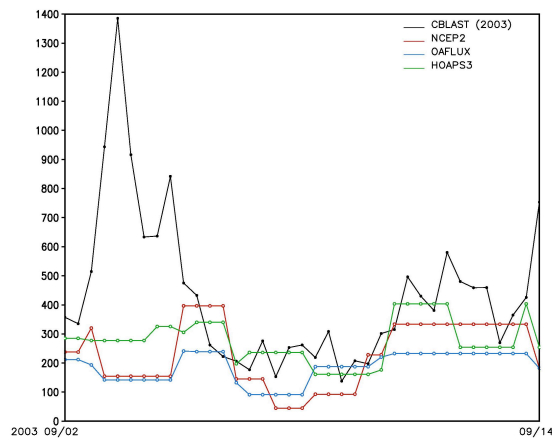
Note: we received the first half our year 4 funding in March 09, and the second half in June 09, hence research with the 4<sup>th</sup> year funds is still underway

- Completion of new surface flux product for Jan. 1999-Jun. 2005

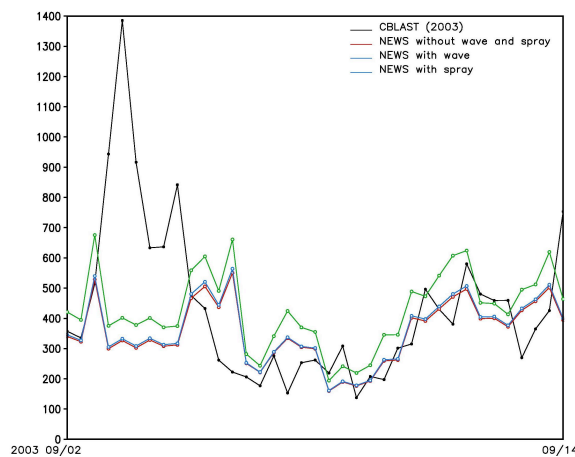
We have completed processing using the new flux algorithm with wave spectra, the merged surface wind speed data set, the high resolution SST data set, and the new  $T_a$ ,  $q_a$  dataset.  
(<ftp://crew.iges.org/NEWS/JipingLiu/NEWS>)

- Extension to conditions of very high winds

A new surface roughness model developed by M. Bourassa of Florida State University has been combined with the Clayson/Curry surface renewal bulk turbulent flux model, a sea spray parameterization, and ocean wave data. Evaluation of the satellite derived fluxes in hurricane conditions are illustrated below. The NEWS product better represents the observed surface latent heat fluxes than other NWP and satellite-derived products for high wind conditions observed in hurricanes.



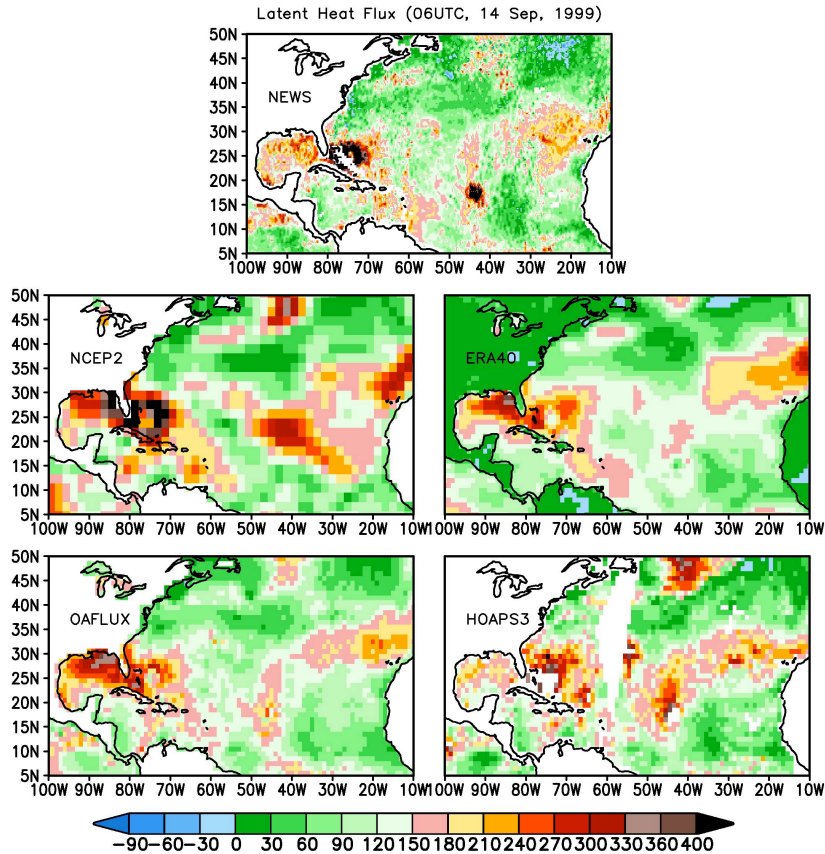
Comparisons of surface latent heat fluxes from CBLAST (in situ observations) and other NWP and satellite data sets



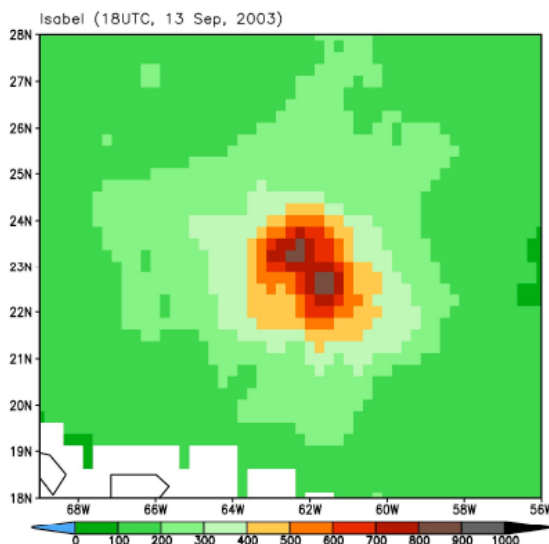
Comparisons of surface latent heat fluxes from CBLAST (in situ observations) NEWS satellite fluxes

- Surface latent heat fluxes in hurricanes

The new surface flux data set using the flux model for high wind speed conditions is applied to North Atlantic hurricanes during the period 1999-2004, and the role of latent heat flux in overall hurricane energetics is investigated.

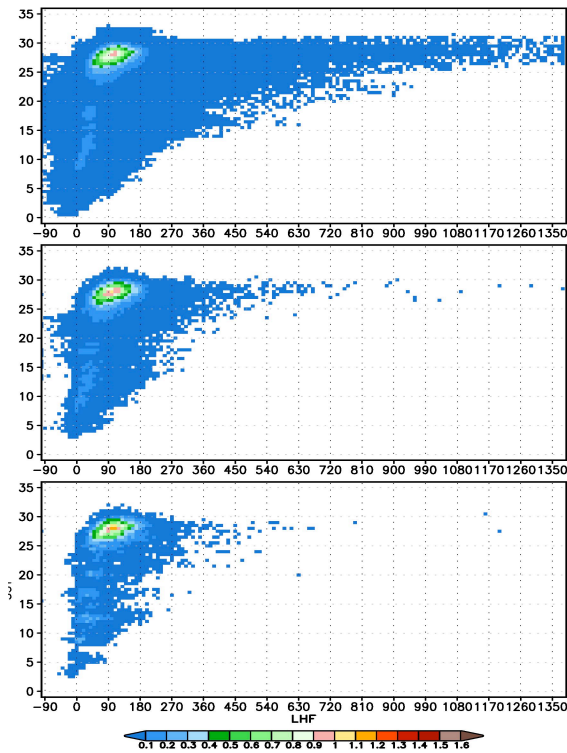


Comparisons of latent heat flux of North Atlantic hurricanes for NEWS and other products from NWP, satellite. Including Hurricanes Floyd and Gert



- SST-latent heat flux feedback

As the initial steps in a broader study on the ocean surface latent heat feedback using the satellite data set, we have investigated the impact of averaging scale on the LH-SST joint PDF. It is seen that as resolution decreases, high values of latent heat flux are lost and the average latent heat flux decreases.



Joint PDF of latent heat flux and sea surface temperature for different horizontal resolution (upper: 0.25 degree, mid: 2.5 degree, lower: 5 degree) for the North Atlantic Ocean

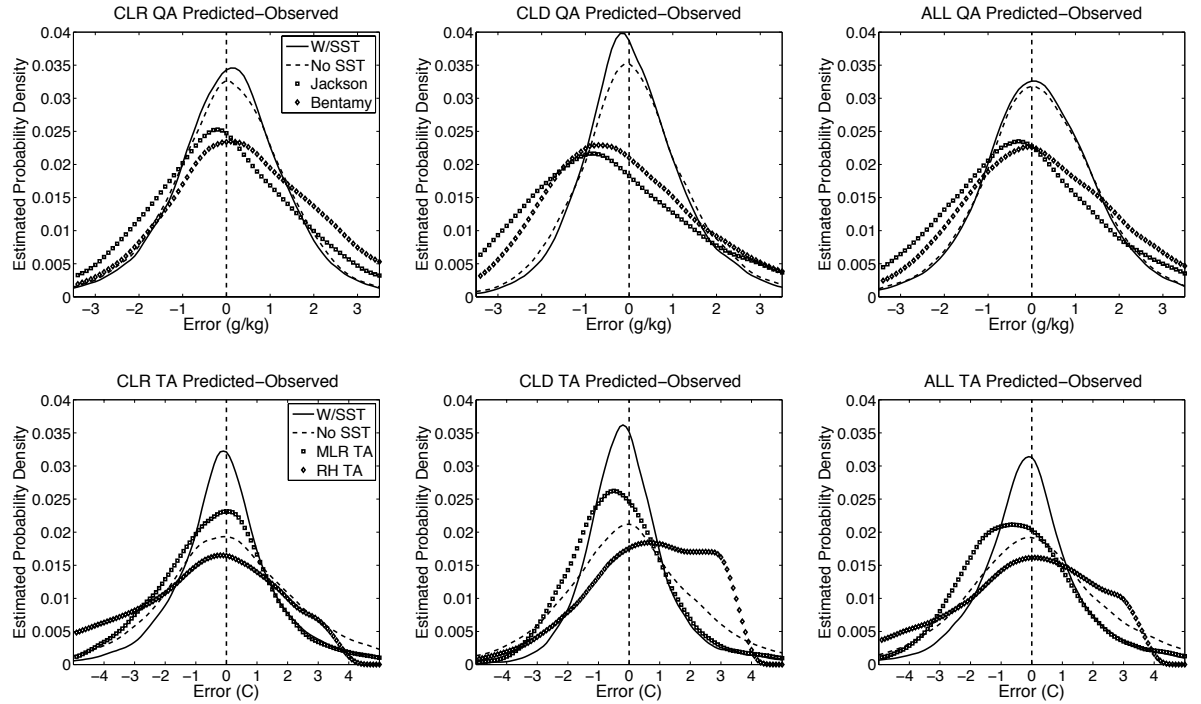
- Evaluation of and improvements towards sea surface temperatures and fluxes

We are continuing investigations into the impact of variable satellite inputs towards the short-term variability and long-term climatology of available satellite data sets. As the number of satellites increases past two, the high frequency components of the signal decrease. There are also obvious increases in noise at the endpoints of the changes in satellite combinations. In addition, there are clear changes in the long-term climatology that seem to be associated with changes in numbers of input satellites.

We have also been involved with the GHRSSST Diurnal Variability Working Group evaluating our diurnal warming product with available in situ and other satellite data.

We are currently also evaluating the possibility of using a neural network technique to reproduce a radiative transfer model to produce a non-interpolated “foundation” sea surface temperature (work in conjunction with Chris Merchant) that fully accounts for aerosols.

In addition, we have completed a new methodology for surface air temperature and humidity (Roberts et al. 2009) using neural network techniques, improved sea surface temperature inputs, and careful analysis of the effects of cloud liquid water. This technique significantly improves the error characteristics of the air temperature and specific humidity as compared to previous methods. Improvements in predicting near surface wind speed and sea surface temperature (SST) are also seen. An example of the improved error characteristics are shown below.



Estimated probability density function of errors for near surface specific humidity (Qa) and air temperature (Ta) from several methodologies (the final Roberts et al. methodology is listed here as w/ SST). From left to right, the top row depicts the error characteristics for the networks training only for clear-sky conditions, cloudy conditions, and a network trained making no distinction between clear or cloudy conditions. The bottom row depicts the same as the top panel except for Ta. RHTA refers to the estimate based on assuming a constant relative humidity.

## Publications/Presentations

- Clayson, C.A., J. B. Roberts, A. Andersson, A. Bentamy, M.A Bourassa, J.A. Curry, D. Jackson, C. Klepp, M. Kubota, W.B. Rossow, J. Schulz, S.R Smith, Tomita, G.A. Wick' 2009: Results of the SeaFlux Intercomparison Project, Bull. Amer. Meteorol. Soc., to be submitted September 1.
- Bogdanoff, A., C. A. Clayson, and J. B. Roberts, 2009: Calculation of Sea Surface Temperature using a Forward Radiative Transfer Model Approach. GHRST User Meeting, June, 2009.
- Clayson, C. A., 2009: SeaFlux Needs and Diurnally-Varying SSTs. GHRST DVWG meeting, Rome, Italy.
- Roberts, J. B. and C. A. Clayson, 2008: Investigating the geospatial and temporal patterns of diurnal warming events using remote sensing and modeling. AGU Ocean Sciences Meeting, Orlando, FL.
- Clayson, C. A., 2008: Diurnal sea surface temperature variability and the transition phase of the MJO. AMS 28<sup>th</sup> Conference on Hurricanes and Tropical Meteorology, Orlando, FL.
- Roberts, J. B., C. A. Clayson, F. R. Robertson and D. Jackson, 2009: Predicting near-surface characteristics from SSM/I using neural networks with a first guess approach. Journal of Geophys. Res., submitted.
- Liu, J., J.A. Curry, C.A. Clayson, Satellite-derived surface latent heat fluxes in North Atlantic hurricanes, in preparation.
- Fritz, A.M., J. Belanger, J.A. Curry, Impact of hurricane size on the energetics of North Atlantic tropical cyclones. Geophys. Res. Lett., (to be submitted August 09)
- Liu J., J.A. Curry et al., A.M. Fritz, J. Belanger, The role of ocean surface heat flux in North Atlantic hurricane energetics, in preparation
- Clayson, C. A. Uncertainties in surface fluxes: The way forward. 12<sup>th</sup> U.S.-Japan Workshop on Global Change. Hosted by NSF and MEXT. Boulder/Broomfield, Colorado, 2 July 2008.
- Clayson, C. A. Joint EUMETSAT Meteorological Satellite Conference and 15<sup>th</sup> AMS Satellite Met. And Oceanogr., Conference, Amsterdam, The Netherlands, 26 September 2007. (Keynote). Title: An overview of SeaFlux: New science and methods in air-sea fluxes.
- Roberts, J. B., C. A. Clayson, F. R. Robertson, and D. Jackson, 2008: Investigating seasonal and interannual variability of latent heat flux using a high resolution satellite product. *Eos Trans. AGU* 89(23), Jt. Assem. Suppl., Abstract U33C-03.
- Clayson, C. A., 2008: An overview of SEAFLUX: New science and methods in air-sea fluxes. *AGU Ocean Sciences Meeting*, Orlando, FL.
- Roberts, J. B. and C. A. Clayson, 2008: Investigating the geospatial and temporal patterns of diurnal warming events using remote sensing and modeling. *AGU Ocean Sciences Meeting*, Orlando, FL.
- Romanou, A., W. B. Rossow, C. A. Clayson, and R. Roehrig, 2008: Latent heat flux variability in the tropical Pacific from observations and models. *AGU Ocean Sciences Meeting*, Orlando, FL.
- Liu, J., and J. A. Curry, Variability of the tropical and subtropical ocean surface latent heat flux during 1989-2000, Geophys. Res. Lett., 33, L05706, doi:10.1029/2005GL024809, 2006
- Liu, J., J. A. Curry, et al., 2009: Evaluation of Satellite Sea Surface Temperature in the Southern Hemisphere Using Chinese Antarctic Research Cruise Observations, Int. J. Remote Sensing, in press.
- Liu, J., J. A. Curry, et al., Southern ocean warming: faster than projections, to be submitted, 2008.
- Romanou, A., "Warm Pool Latent Heat Flux from satellites and IPCC-AR4 models, " presented at the COSPAR meeting, July 2006
- Romanou, A., B. Liepert, G.A. Schmidt, et al. 1007, 20<sup>th</sup> century changes in surface solar irradiance in simulations and observations. Geophys. Res. Lett. 34, Art. No. L05713.
- Clayson, C.A., SEAFLUX presentation made at the 2005 GEWEX Radiation Panel Meeting

- Clayson, C.A., "Seaflux Intercomparisons", SEAFLUX 3rd Workshop, Wakulla Springs, FL, March 2 - 3 , 2006.
- Clayson, C.A. and Weitlich, 2007: Variability of tropical diurnal sea surface temperature. *J. Climate*, 20, 334-352.
- Clayson, C.A., SEAFLUX: New methods in satellite-derived air-sea fluxes. AGU Joint Assembly, Acapulco, Mexico, May, 2007.
- Clayson, C.A., An overview of new science and methods in air-sea fluxes. Keynote Address, Joint EUMETSAT/AMS Conference on Satellite Meteorology and Oceanography, Amsterdam, The Netherlands, September, 2007.
- Haman, C. and C. A. Clayson, Effects of a diurnal SST on surface fluxes and atmospheric variability. AMS 19<sup>th</sup> Conference on Climate and Climate Variability. San Antonio, January, 2007.
- Romanou, A., Turbulent fluxes at the surface of the ocean from models and observations. #rd WGNE Workshop on Systematic Errors in Climate and NWP Models. San Francisco, Feb 12-16, 2007
- Romanou, A. Comparisons of Large-Scale Satellite-Based Observations of Air-Sea Heat and Water Fluxes with Models. AGU Ocean Sciences Joint Assembly, Acapulco, Mexico, 21-25 May 2007
- Romanou, A. et al., High Resolution Simulations of the Mediterranean Sea. Layered Ocean Model Meeting, August 0-22 2007, Bergen, Norway
- Romanou, A. Evaporation flux variability in the tropical Pacific from different satellite derived datasets and climate models. Joint EUMETSAT Meteorological Satellite Conference and and 15<sup>th</sup> Satellite Meteorology and Oceanography Conference of the AMS. SEAFLUX Workshop.

### **Work plan for Year 5**

- Final project data set, 10+ years
- Complete studies that apply the datasets (ocean model simulations, energy balance studies)
- Submission of final journal articles

### **NEWS connections and interactions**

*SEAFLUX workshop:* On Sept 24-28 2007, the 4<sup>th</sup> SEAFLUX workshop was held in Amsterdam (organized and chaired by C.A. Clayson), in conjunction with the Joint EUMETSAT Meteorological Satellite Conference and and 15<sup>th</sup> Satellite Meteorology and Oceanography Conference of the American Meteorological Society. This workshop brought together the international community involved in satellite ocean surface flux products, including a number of NEWS investigators. A 5<sup>th</sup> SeaFlux workshop is being planned for mid-March, 2010 in Boulder, in conjunction with the CLIVAR High-Latitude workshop. At this time we will be demonstrating our satellite flux dataset for comparisons.

*Integration:* Our model is providing a 10+ year data set that can be used to evaluate coupled climate model simulations and conduct diagnostic studies to improve understanding of the water and energy cycle variability on time scales from the diurnal to the decadal. We are collaborating with Wentz, Liu, Adler, Wielicki in integrating the surface flux datasets over the ocean. We anticipate that our products will be used by Soden, Bosilevech, Rossow.